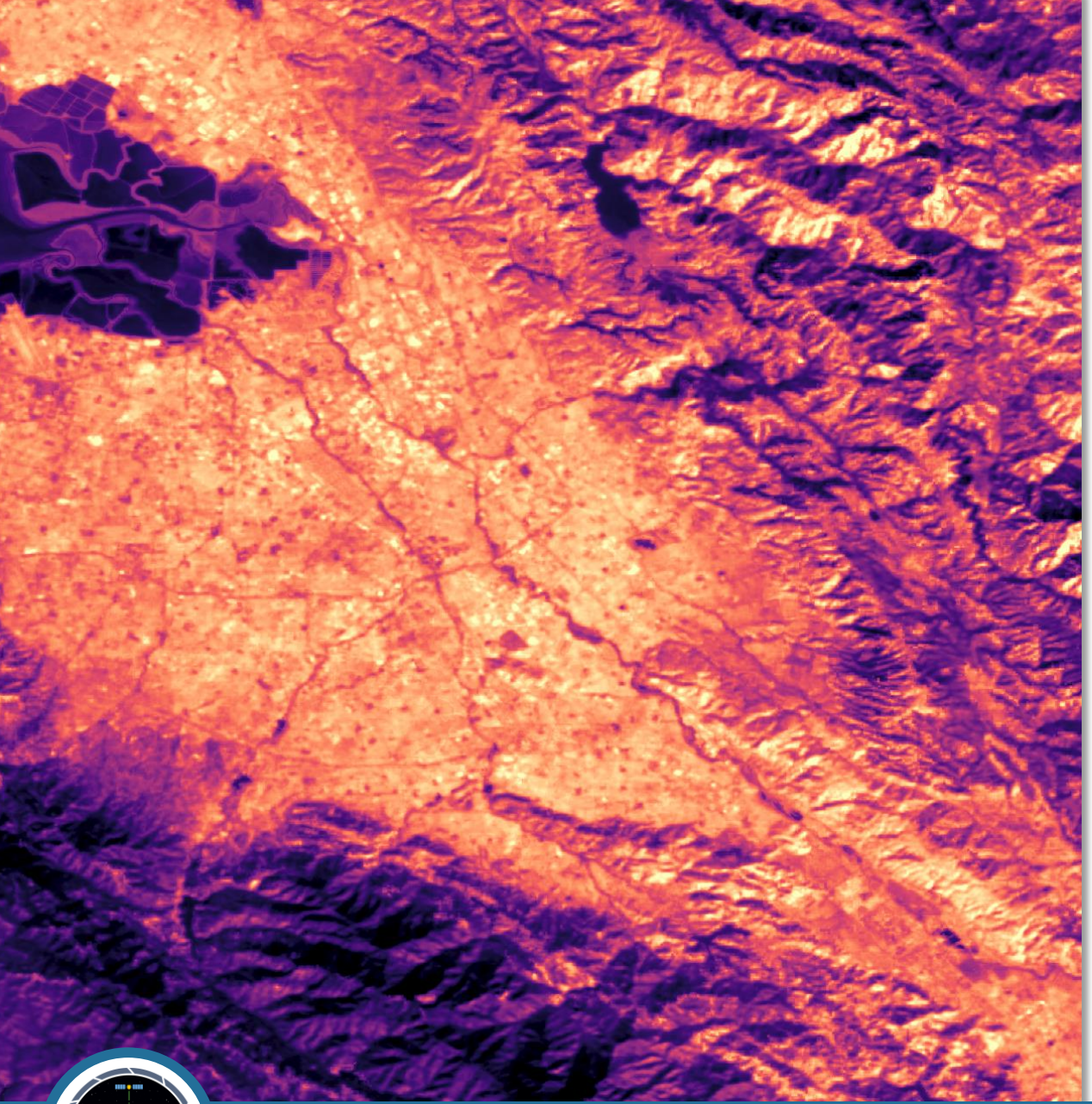


National Aeronautics and Space Administration

SAN JOSÉ URBAN DEVELOPMENT

Quantifying Canopy Cover and Land Surface Temperature in San José to Identify Future Tree Planting Sites

Shilpa Kannan

Kathleen Miller

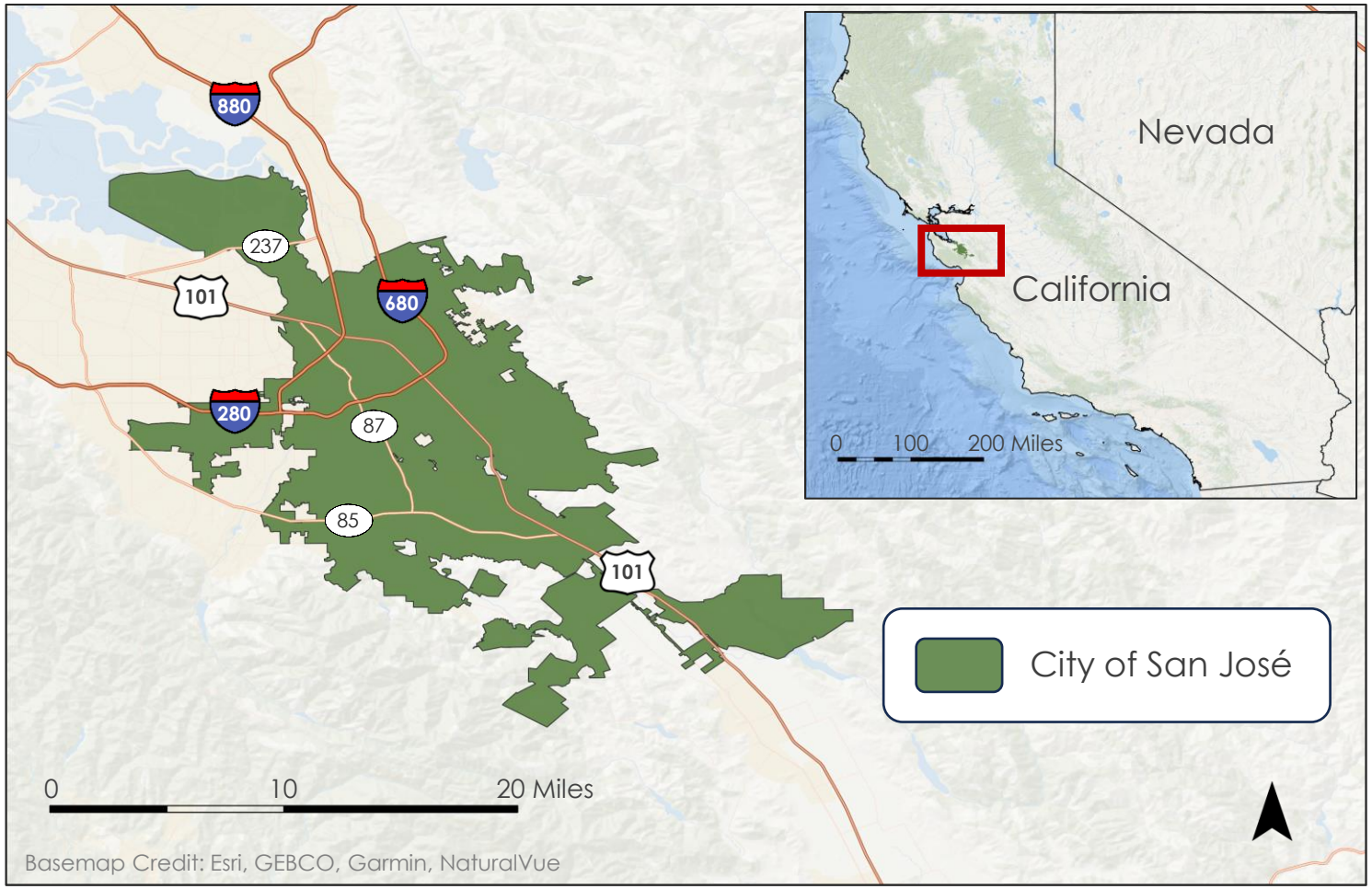
Patrick Kerwin

Emeline Tu

DEVELOP

California – Ames | Fall 2024

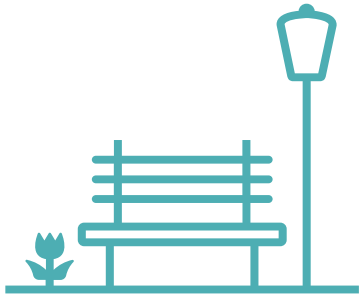
STUDY AREA/PERIOD



- **Study Area**
  - City of San José, California
    - Population: 969,655 (2023)
    - Area: 178 mi^2 (461 km^2)
- **Study Period**
  - 2013 to 2024
    - Growing Period: May & June

PARTNERS

City of San José Department of Parks, Recreation and Neighborhood Services



City of San José Department of Transportation

Image credit: Lauren Webster

URBAN HEAT ISLAND (UHI) EFFECT

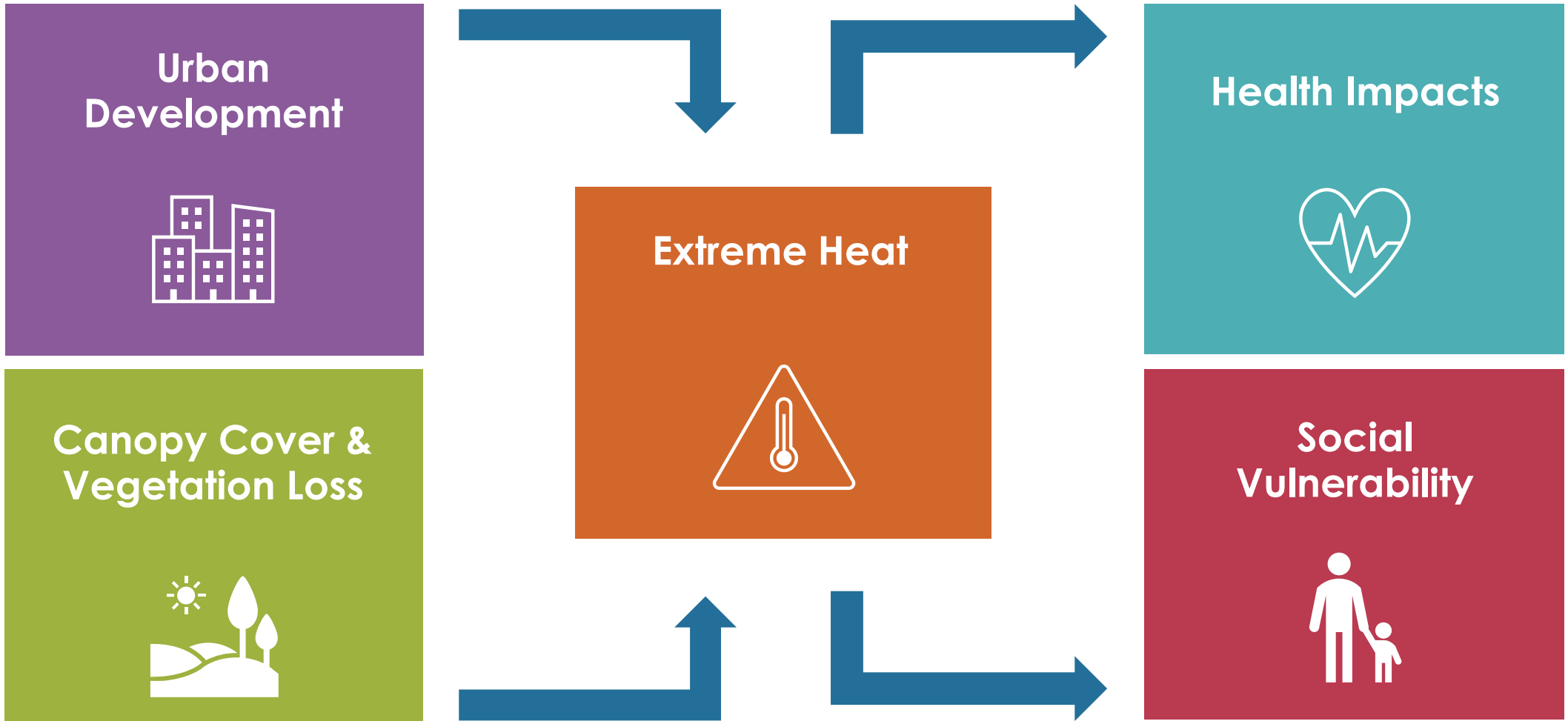
Causes include:

- High concentration of impervious surfaces
- Restricted airflow between buildings
- Human activity emissions

Mitigation can involve:

- Increasing canopy cover through tree planting

COMMUNITY CONCERNS



OBJECTIVES

INVESTIGATE Urban Heat

- **Use** NASA Earth observations to examine Land Surface Temperature (LST)
- **Create** a Heat Vulnerability Index (HVI) to assess social and environmental factors of heat risk

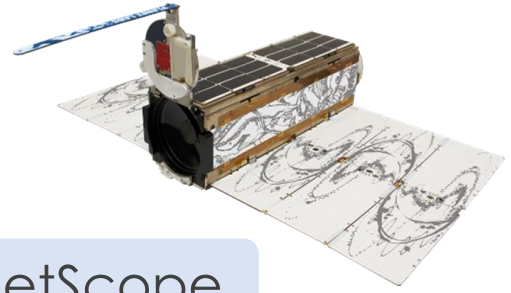
MONITOR Vegetation

- **Analyze** vegetation and land cover changes using Earth observations
- **Assess** canopy cover using Light Detection and Ranging (Lidar) data

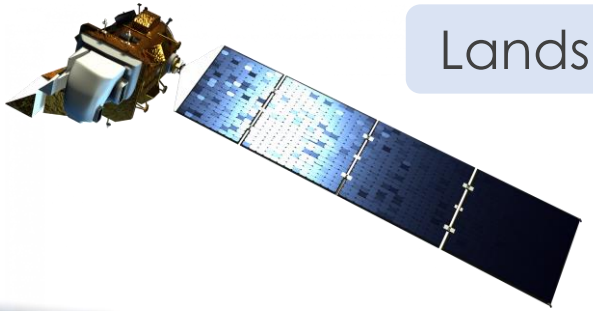
INFORM Urban Forestry Initiatives

- **Provide** useful data visualizations and a Park Report to partners
- **Support** partner efforts to identify new tree planting sites

EARTH OBSERVATIONS



PlanetScope



Landsat 8 TIRS

Lidar

Landsat 9 TIRS-2

Image credits: Flaticon, Planet Labs PBC, NASA

METHODOLOGY: Land Cover

ACQUISITION

National Land Cover Database (NLCD) Land Cover (CONUS) 2013, 2016, 2019, 2021

PROCESSING

Clipped data to study area boundaries in ArcGIS Pro

Filtered land cover classifications for relevance

ANALYSIS

Change Detection Wizard in ArcGIS Pro

Calculated percent of area that increased in development by census tract

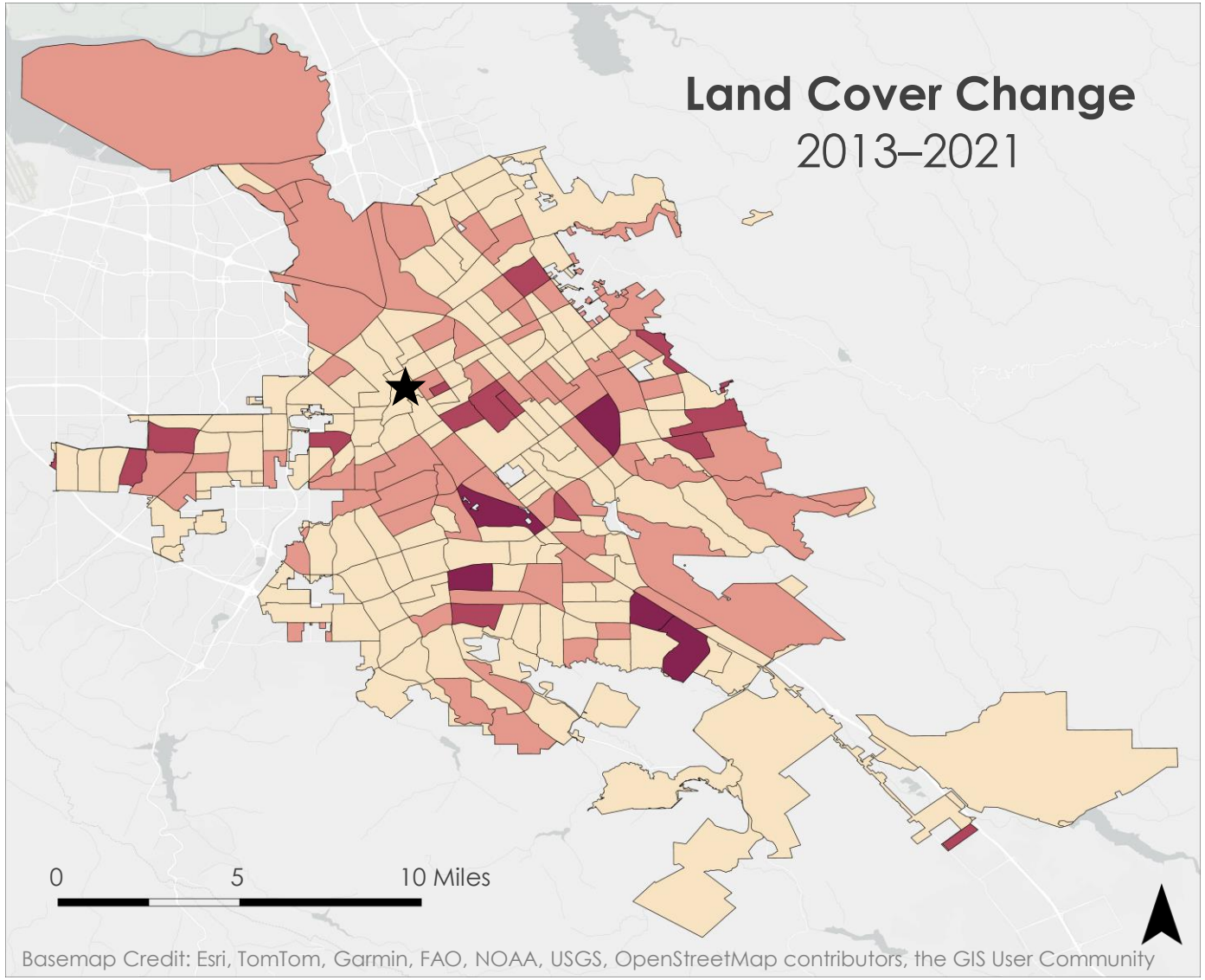
OUTPUTS

Land Cover Map

RESULTS: Land Cover

Percent Area per Census Tract that Increased in Development (%)

- Low Increase (0.0–0.5%)
- Some Increase (0.51–1.5%)
- Medium Increase (1.6–5.0%)
- High Increase (5.1–15.0%)
- ★ Downtown San José



METHODOLOGY: Urban Heat

ACQUISITION

Landsat 8 TIRS and 9 TIRS-2 Imagery 2013–2024

PySTAC Planetary Computer

PROCESSING

Filtered and combined images in Python

LST calculation in Python

Median composite in Python

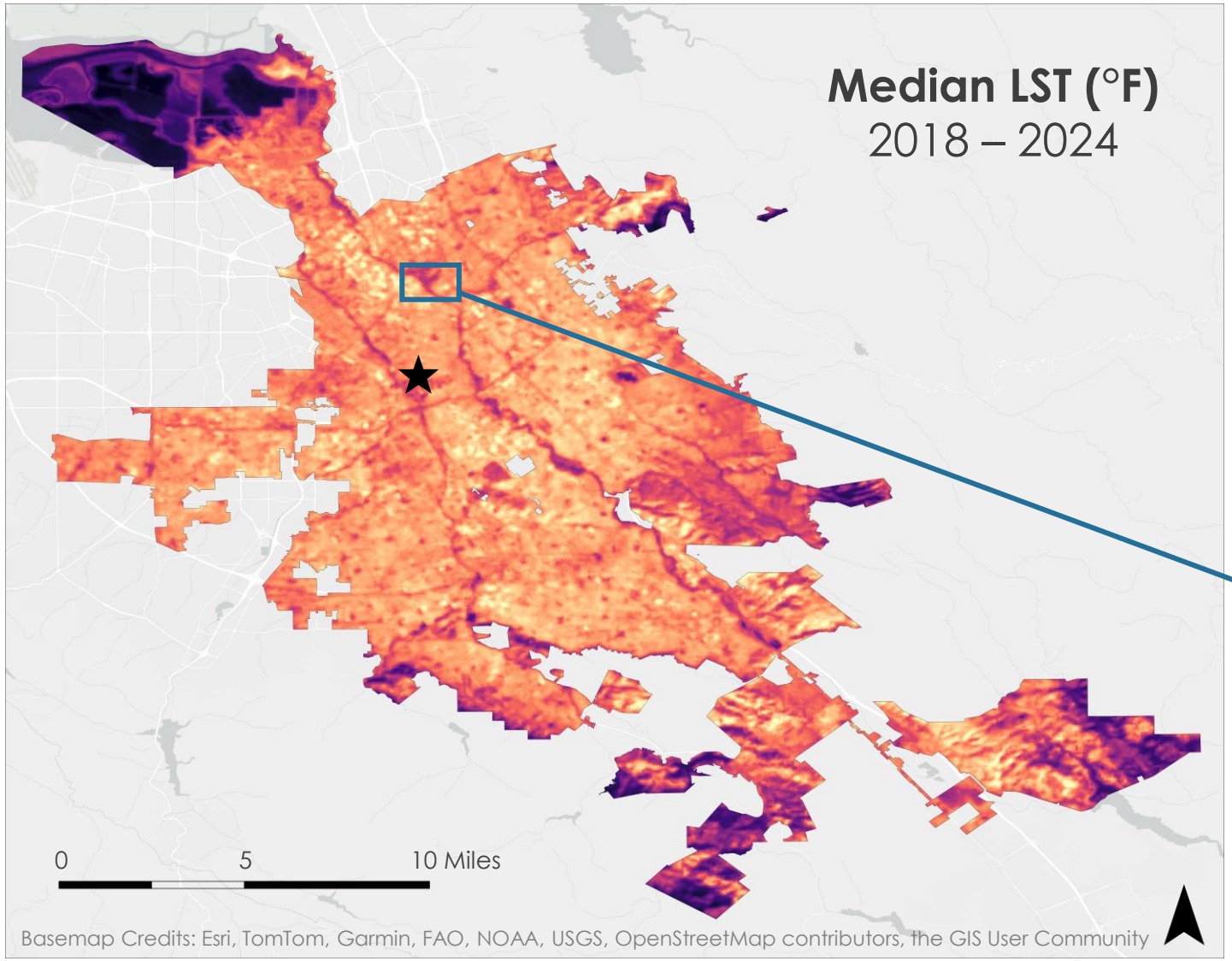
ANALYSIS

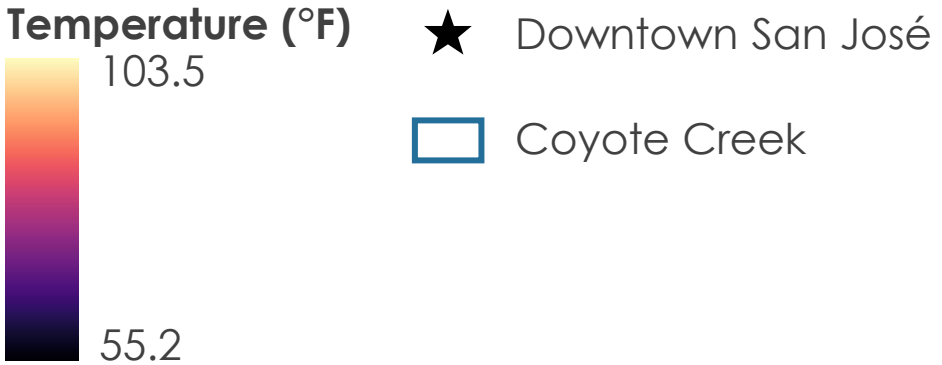
LST/NDVI correlation analysis in R

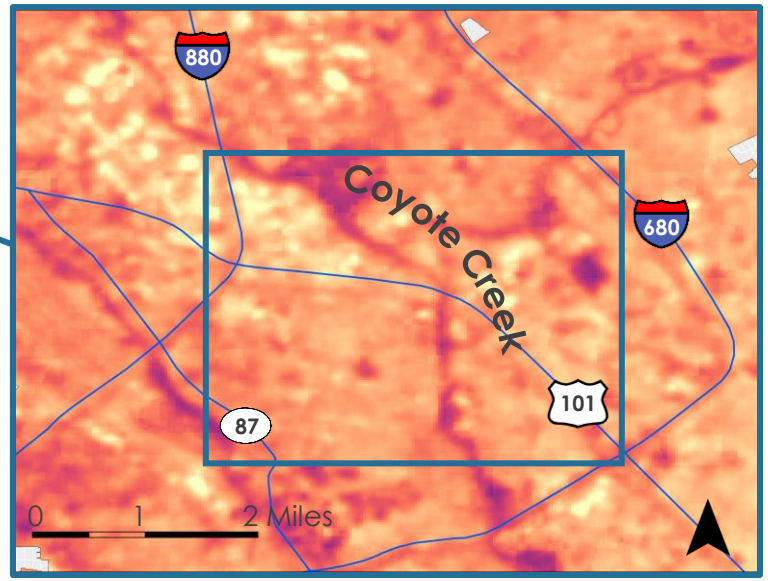
OUTPUTS

LST Map

RESULTS: Urban Heat







METHODOLOGY: Vegetation Greenness

ACQUISITION

PlanetScope Imagery (May composite images for 2018–2024)

PROCESSING

Calculated NDVI for May composites using ModelBuilder

Calculated median NDVI in Python

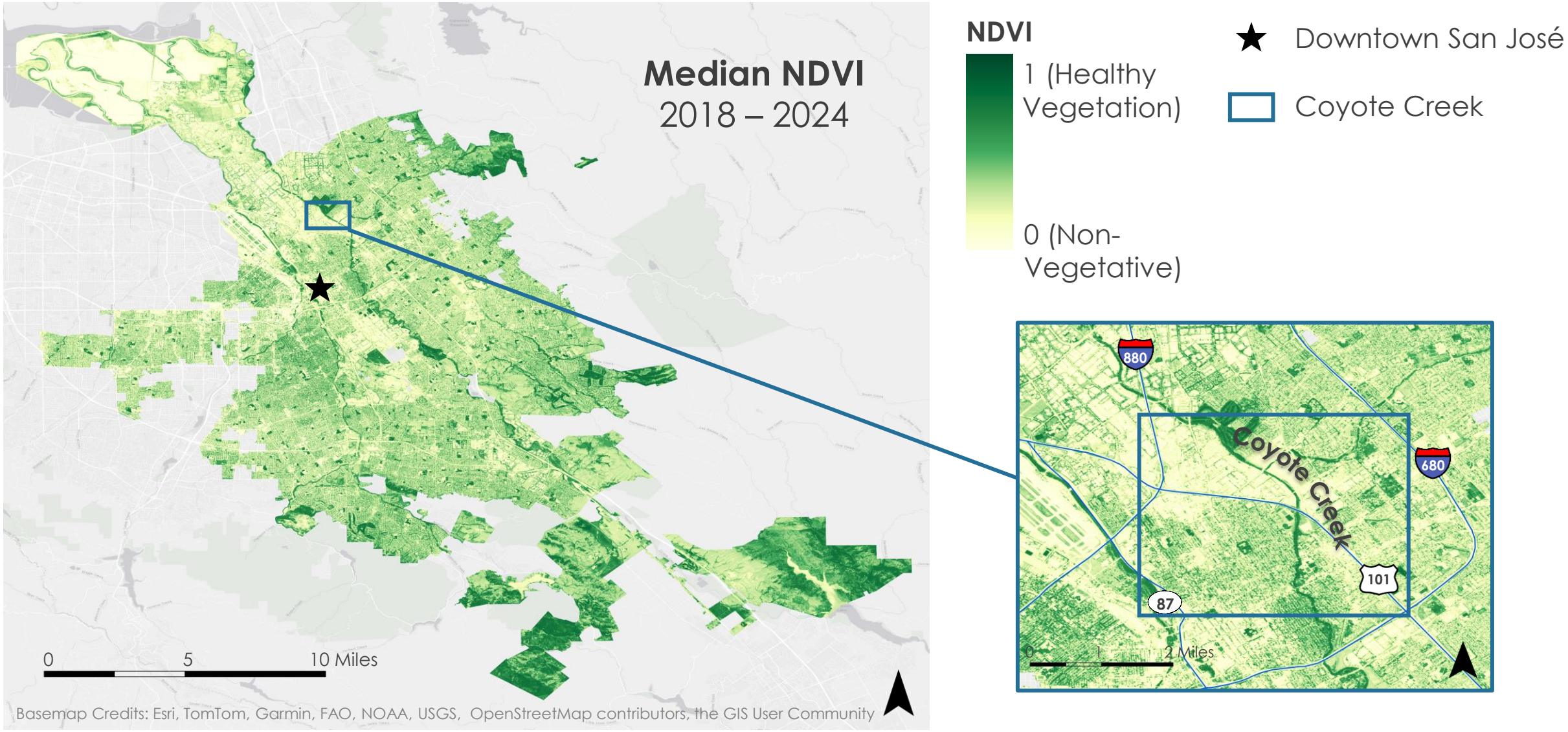
ANALYSIS

LST/NDVI correlation analysis in R

OUTPUTS

NDVI Map

RESULTS: Vegetation Greenness



METHODOLOGY: Canopy Cover

ACQUISITION

2020 Canopy Height Model (CHM)

2020 Lidar Classification

PROCESSING

Used classification layer to extract vegetation from CHM in ArcGIS Pro

Filtered for vegetation > 2 m

Created polygon layer showing canopy cover

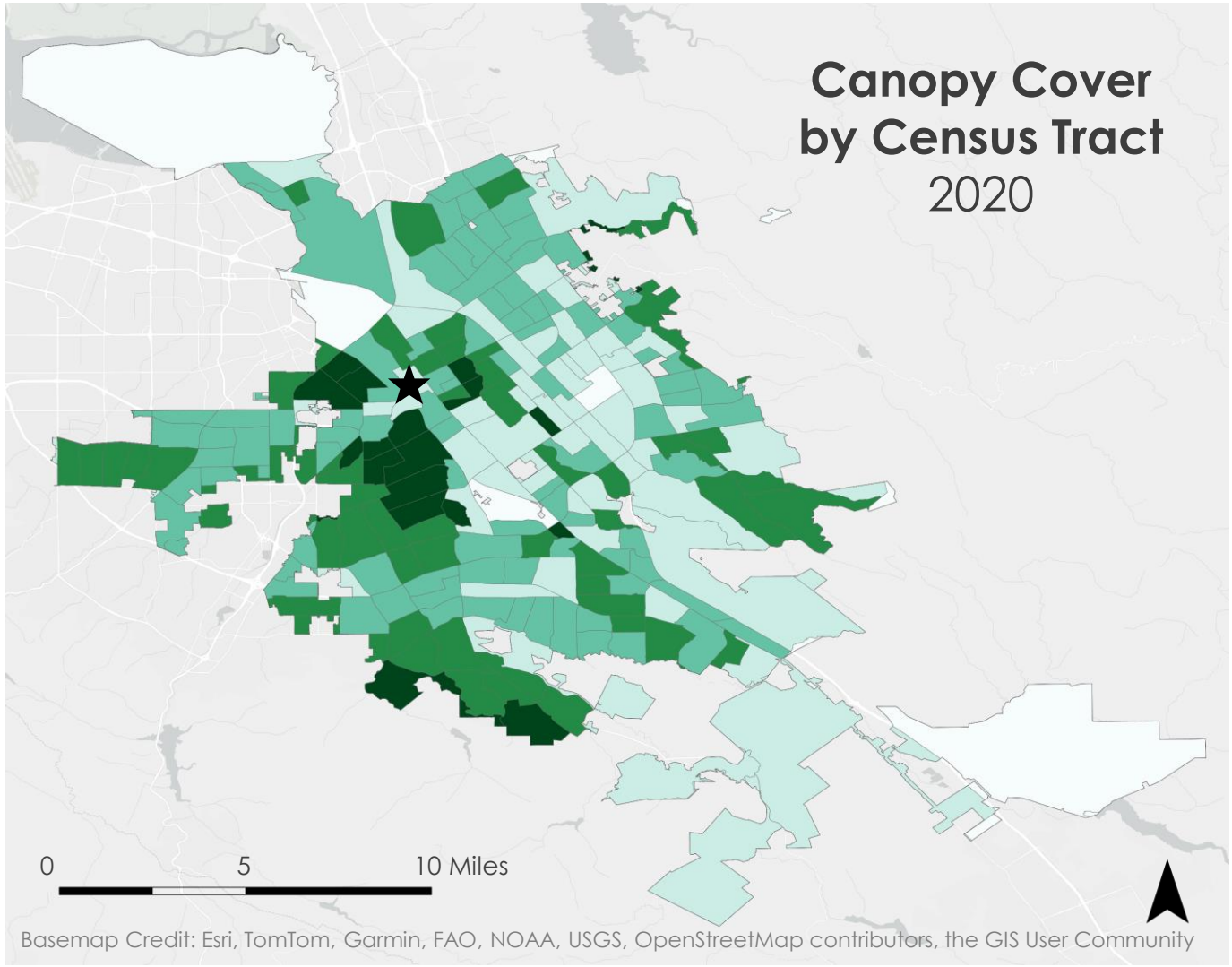
ANALYSIS

Calculated canopy cover area and percent coverage in parks

OUTPUTS

Canopy Cover Map

RESULTS: Canopy Cover



Percent Canopy Cover (%)

- 0–11%
- 11–22%
- 22–28%
- 28–35%
- >35%

★ Downtown San José

METHODOLOGY: Heat Vulnerability Index

ACQUISITION

CDC/ATSDR Social Vulnerability Index 2022

PROCESSING

Cleaned and filtered data to Santa Clara County in R

Created histogram and correlation plots

ANALYSIS

Normalized data and performed PCA in R

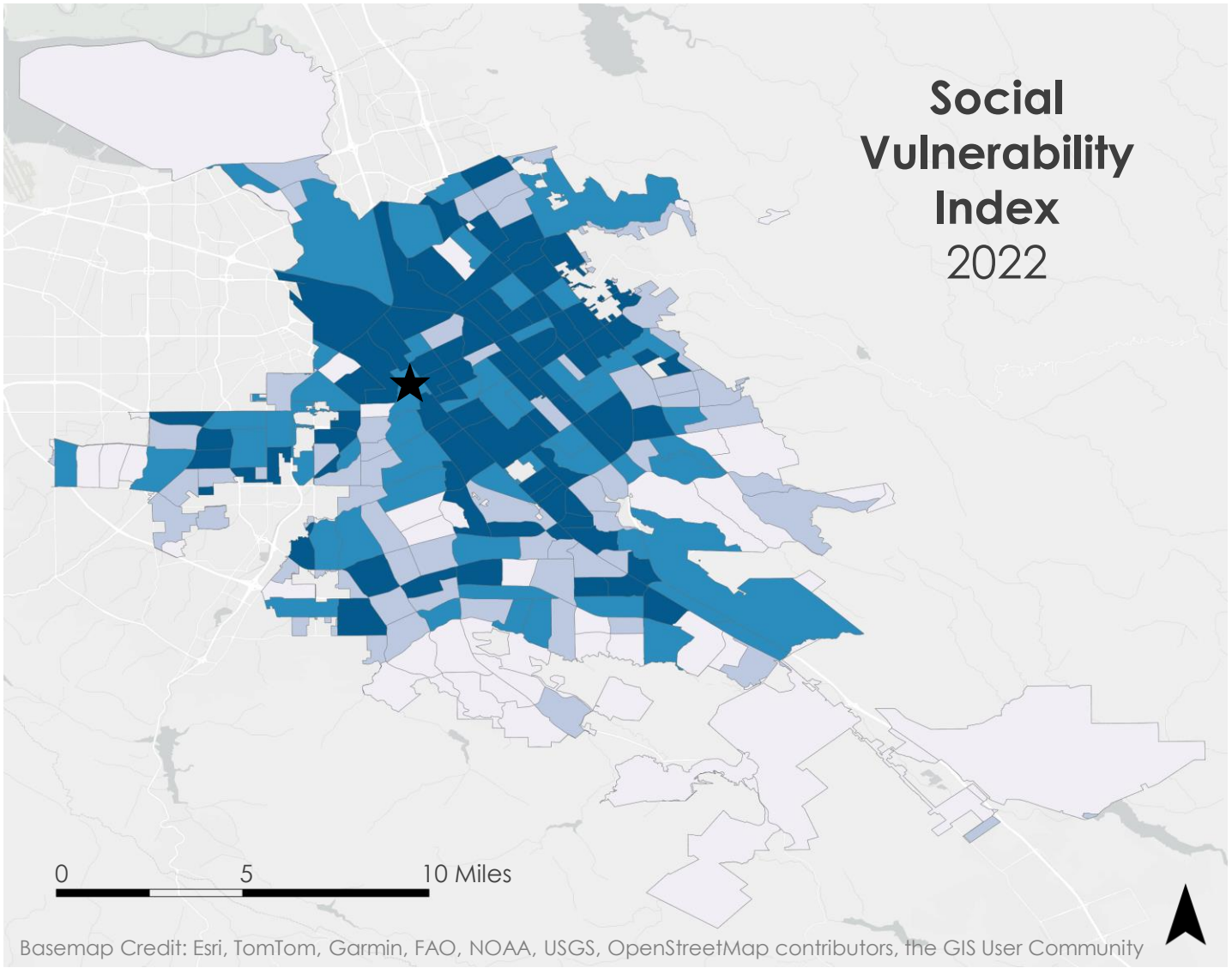
Conducted scoring based on quantiles

Incorporated LST, NDVI, and Canopy Cover Data

OUTPUTS

HVI Scores/Assessment

RESULTS: Social Vulnerability Index

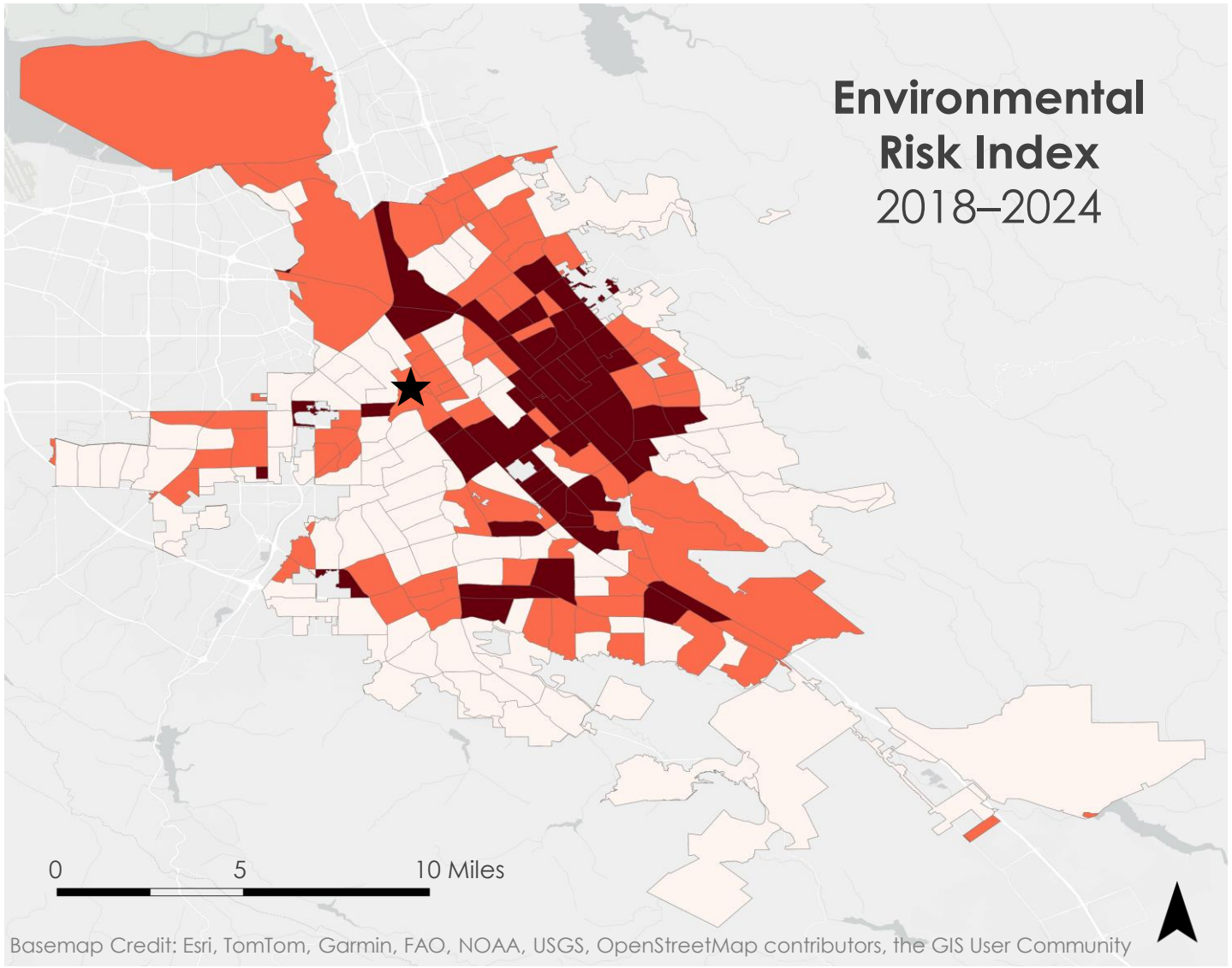


Social Vulnerability Index

- 5–7 (Lowest Vulnerability)
- 8–10
- 11–12
- 13–15 (Highest Vulnerability)
- ★ Downtown San José

SVI Components
150% Poverty
Unemployed
Housing Cost Burden
No High School Diploma
No Health Insurance

RESULTS: Environmental Risk Index

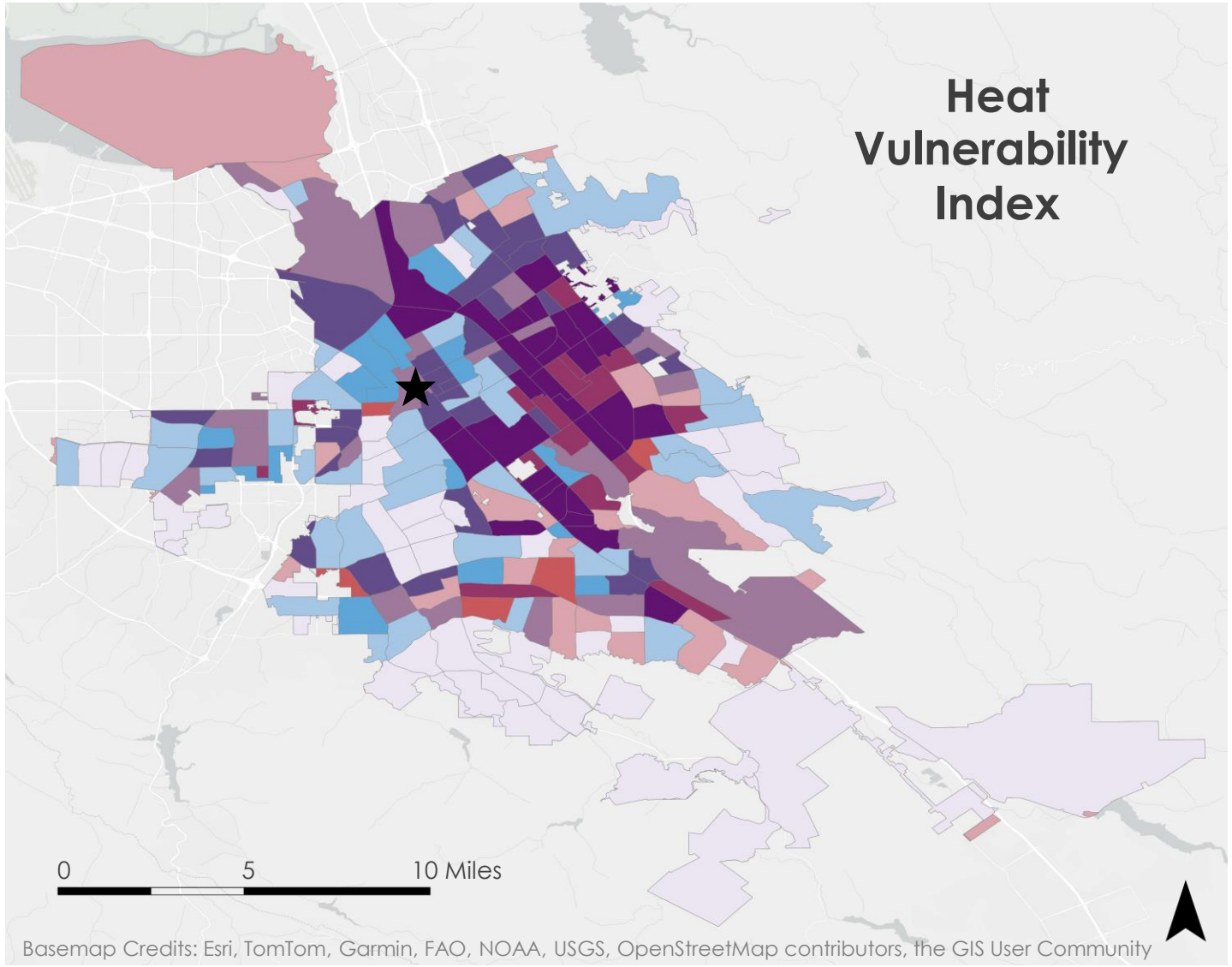


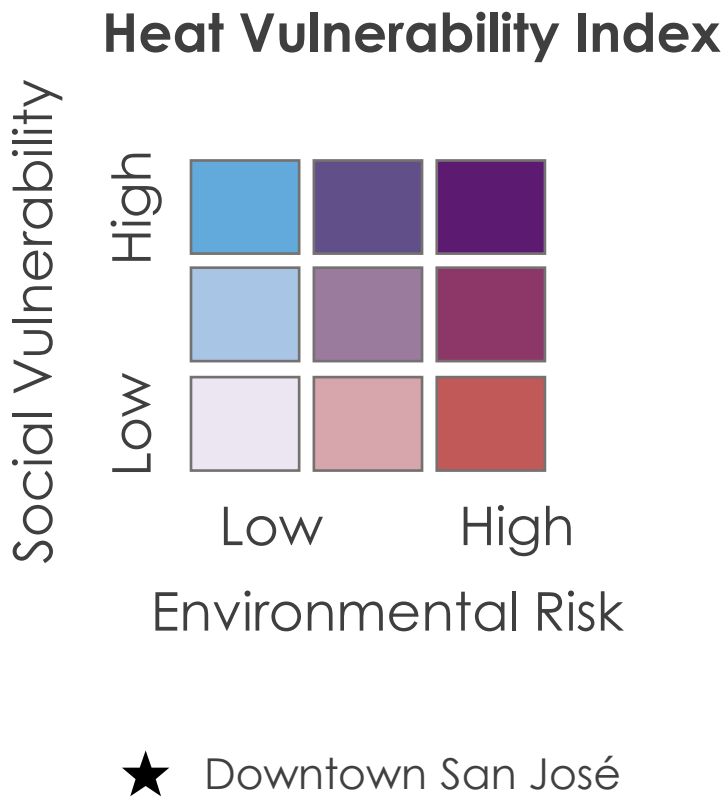
Environmental Risk Index

- 3–5 (Lowest Risk)
- 6–7
- 8–9 (Highest Risk)
- ★ Downtown San José

ERI Components
LST
NDVI
Canopy Cover

RESULTS: Heat Vulnerability Index





ERRORS & UNCERTAINTIES

Data Acquisition

- Varying number of images per month
- Inconsistent spatial resolution across datasets
- Time range restricted by unreliable data

Data Processing

- Imperfect tree extraction
- Difficulties distinguishing tree height (buildings and trees overlapping)

Data Analysis

- In-depth canopy cover analysis is inconclusive due to differing methodology and data sources

FEASIBILITY & PARTNER IMPLEMENTATION

Earth observations can **provide insight** into the relationship between urban heat and land cover, as well as inform urban forestry decision-making.

Lidar data can be used to **assess canopy cover**; however, differing methodology and data sources add complexity.

Project results and end products can be directly incorporated to **identify priority tree planting locations**.

A multifaceted approach to analyzing vegetation cover, social vulnerability, and urban heat **enhances relevancy and utility to partners**.

CONCLUSIONS

- The Urban Heat Island effect is **concentrated in highly developed areas.**
- Census tracts with low vegetation health are on **average 2°F hotter** than census tracts with high vegetation health.
- Nearly **40% of census tracts** with a high social vulnerability score are located in areas of high environmental risk.
- Healthy vegetation levels in parks can **reduce environmental risk** in socially vulnerable areas.

Image credit: Lauren Webster

Acknowledgments

The team would like to thank:

Partners: Kallie Schloemann (City of San José Department of Parks, Recreation and Neighborhood Services) & Nara Baker (City of San José Department of Transportation)

Advisors: Dr. Morgan Gilmour (NASA ARC), Maya Hall (California - Ames), Harrison Raine (NASA ARC), Lisa Tanh (Esri), Xihan Yao (EarthDefine)

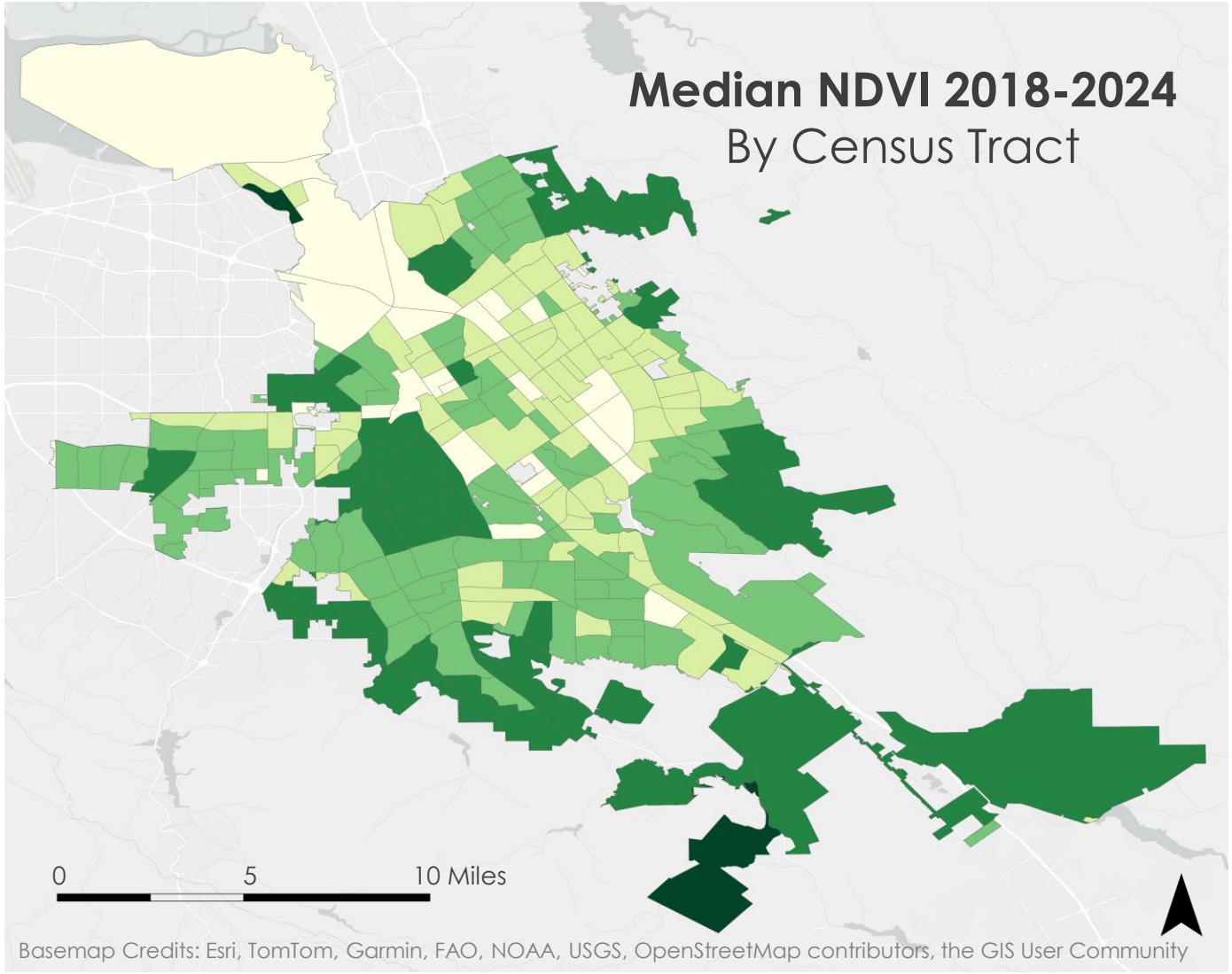
Special Thanks: Kyle Kabasares (NASA ARC)

Lead: Lauren Webster (California - Ames)

This work utilized data made available through the NASA Commercial Smallsat Data Acquisition (CSDA) Program.

This material is based upon work supported by NASA through contract 80LARC23FA024. Any mention of a commercial product, service, or activity in this material does not constitute NASA endorsement. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration and partner organizations.

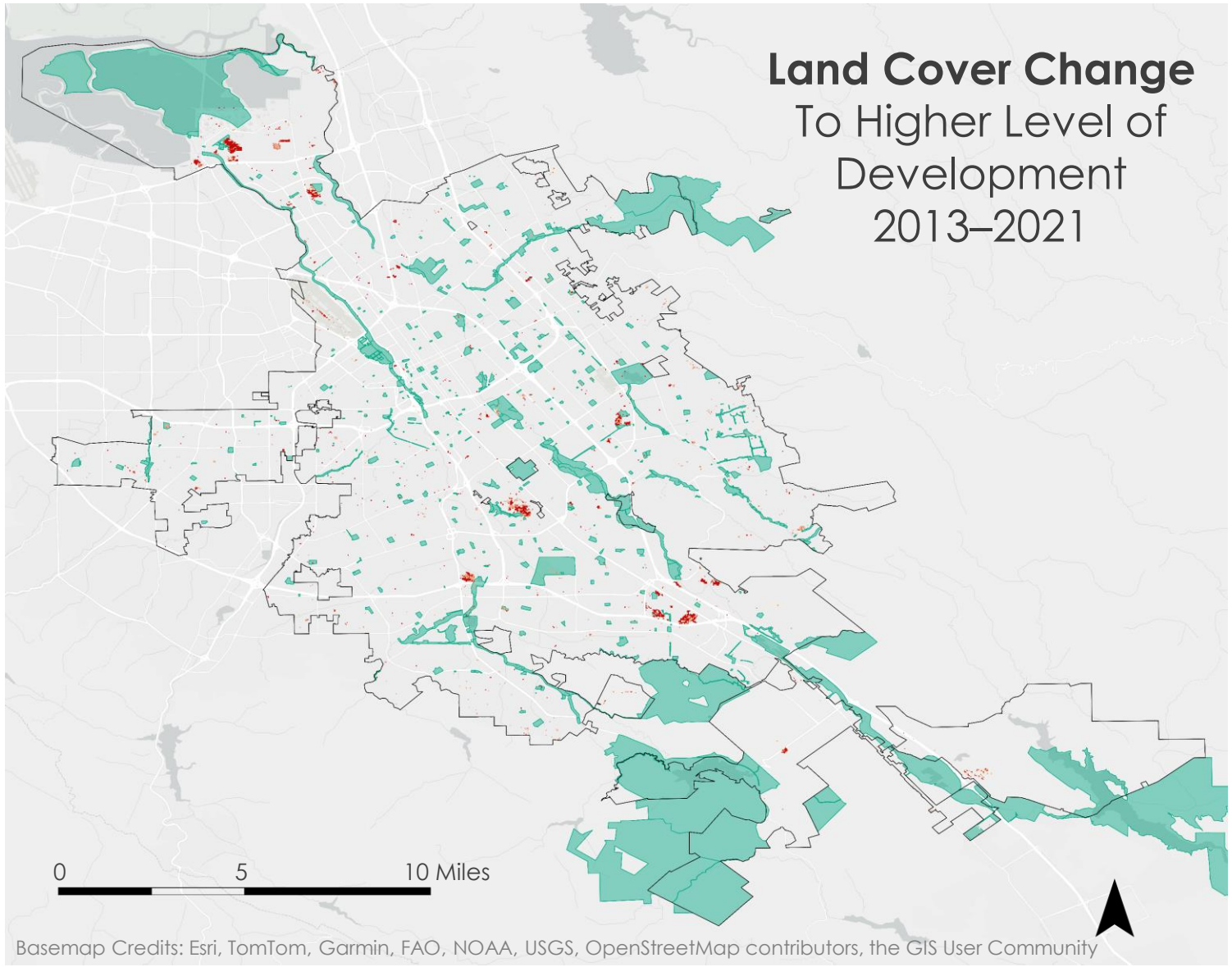
EXTRA SLIDES – PARTNER HANDOFF



Median NDVI

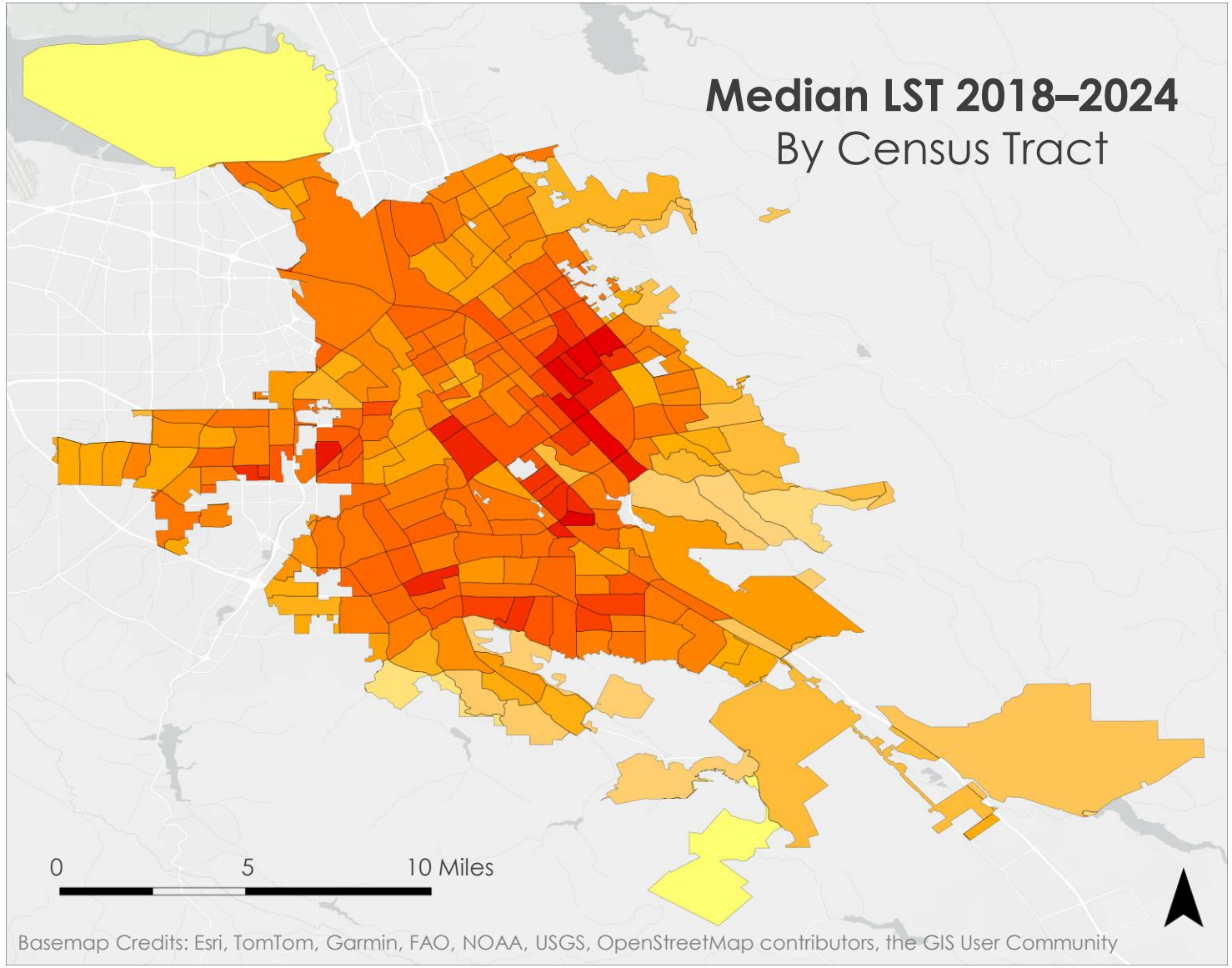
- < 0.22
- 0.22 - 0.27
- 0.27 - 0.33
- 0.33 - 0.43
- 0.43 - 0.71

EXTRA SLIDES – PARTNER HANDOFF



- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Park

EXTRA SLIDES – PARTNER HANDOFF

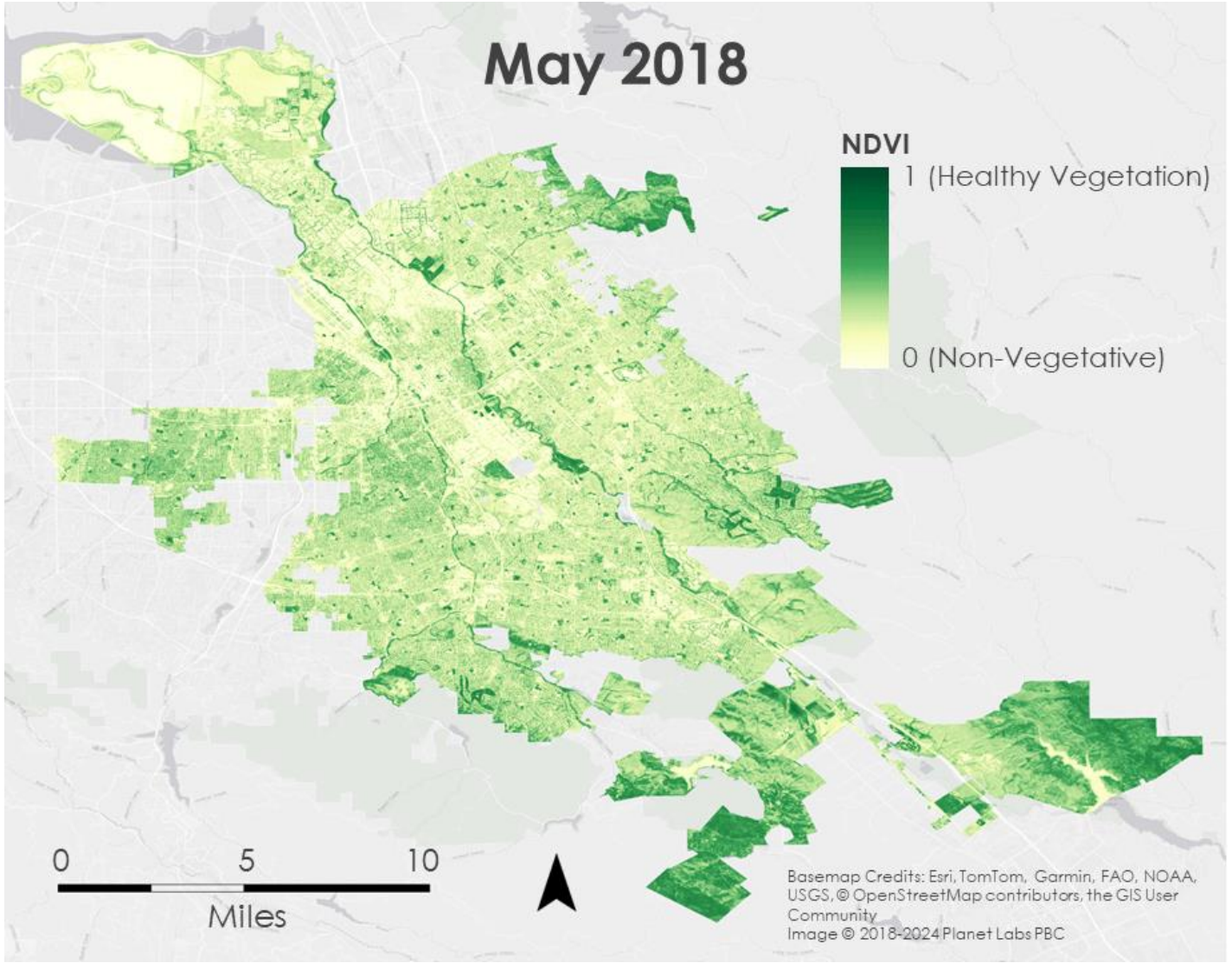


Median LST (degrees °F)

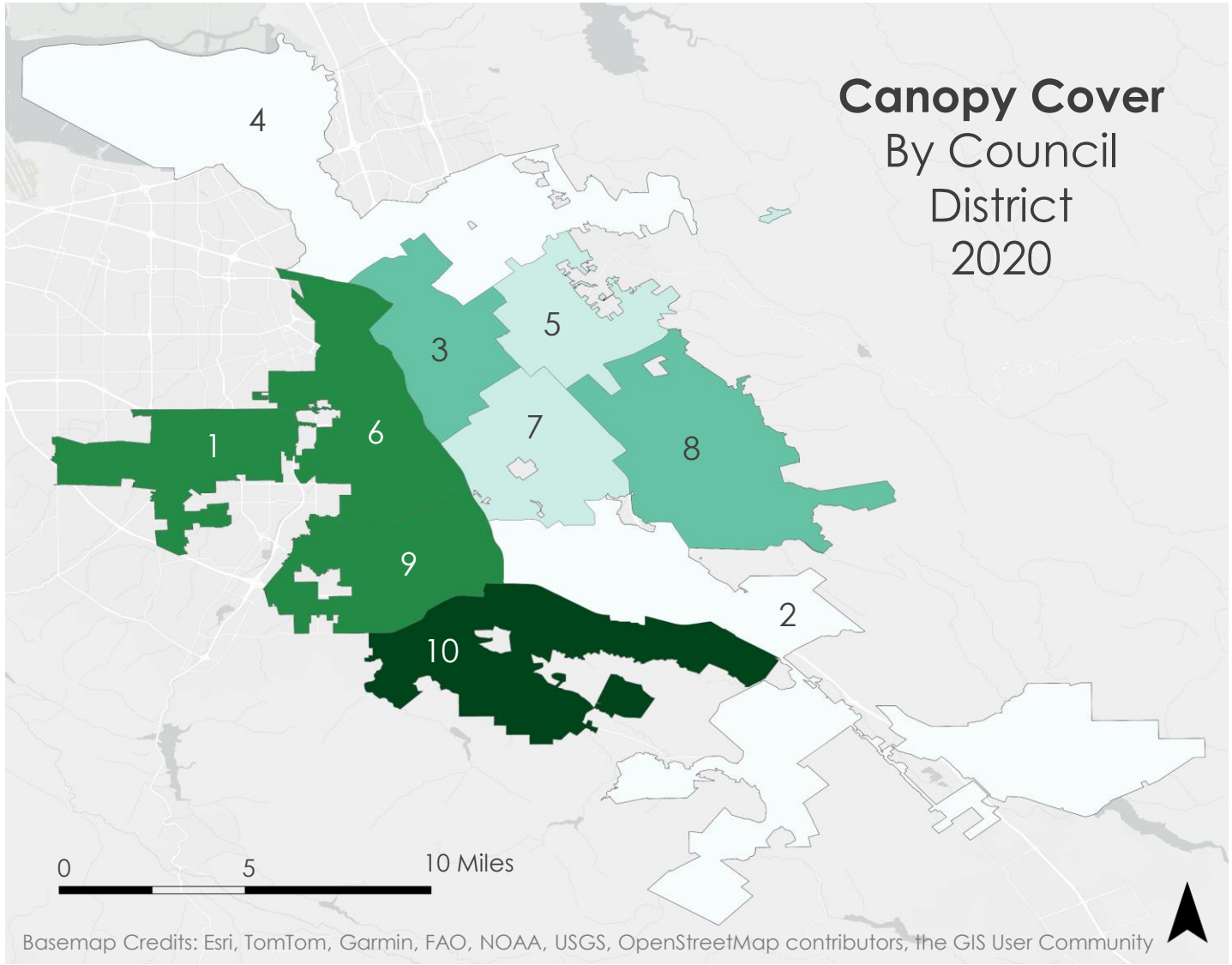
88

69

EXTRA SLIDES – PARTNER HANDOFF



EXTRA SLIDES – PARTNER HANDOFF



Percent Canopy Cover (%)

- 0 – 13%
- 13 – 22%
- 22 – 24%
- 24 – 28%
- >28%